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Growth and Yield of Tomato (*Lycopersicum esculentum (L) Moench*) to Organic Based Fertilizer, Mineral Fertilizer and *Azotobacter croococcum*

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Abstract:
Field experiment was carried out in Lanlate rainforest zone of Southwest Nigeria to study the effect of Organic based fertilizer, Mineral fertilizer and Azotobacter croococcum to the growth and yield of Tomato (Lycopersicum esculentum (L) Moench). The soil at the experimental site is low in Nitrogen and Potassium. The treatment were replicated three times on tomato plant, there were also six treatments; Control (C), Cassava waste - based organic fertilizer (OBF) 5tonnes/ha, Cassava waste - based organic fertilizer + Azotobacter croococcum (OBF+AC), Mineral fertilizer (MF), N: P: K 20:10:10 (60kg/ha), Mineral fertilizer + Azotobacter croococcum (MF+AC) and Azotobactcr croococcum (AC). The Mineral fertilizer (MF) increased significantly the plant growth at 3WAT while Organic based fertilizer + Azotobacter croococcum were found to have increased in the growth of tomato at 5WAT. The Organic base fertilizer (OBF) produced the highest value of dry matter of shoot (13.329)with Azotobacter croococcum recording the lowest value (4.758) even significantly lower than the control (5.739). also tomato fertilized with Mineral fertilizer (MF) gave the greatest yield (46.74t/ha). The weight was significantly higher than that obtained when Azotobacter croococcum (AC) was solely applied or combined with Mineral fertilizer.

Keyword: Fertilizer, Mineral, Organic, Tomato, Azoobacter

INTRODUCTION

In Nigeria, straight fertilizers such as urea, single super-phosphate and muriate of potash (potassium chloride) were the first set of fertilizer sources widely imported or produced for cereal production. Along with this, the bulk of compound fertilizer used in the country were in form of N.P.K. 15-15-15 which is popular with peasant farmers due to lower costs involved in its use on the field and compared with using the straight fertilizers. The compound fertilizer contains N, P and K in ratio 1:1:1 lacks sulphur and its continuous use may cause nutrient imbalance in the soil.

Tomato is cultivated under rain fed and in irrigated areas on a wide range of soils. The production in Nigeria often recorded low yield, the low yield experience has been attributed to poor soil fertility and deficiency in important mineral nutrients and most farmers rely mainly on innate fertility of the soil. Soil productivity and fertility can be maintained by the use of soil amendment in form fertilizer **[1].** Soil fertility depletion in the smallholder farms is the fundamental biophysical root cause for declining per capita food production in sub-Saharan Africa.

In Nigeria, tomatoes are used in large

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quantities as compared with other vegetable crops and therefore it becomes imperative that local production be able to meet local consumption. However, this is not the case. This has resulted in high importation of tomato and tomato products to meet the deficit, which has a negative effect on the nation's economy. Nigeria soil has a high potential for crop production but yield levels obtained under farmer's conditions are usually low due to poor soil management and conservation method.

In an effort to promote better efficiency of fertilizer use, a number of compound fertilizer formulations have been manufactured in the country. These fertilizers are N.P.K. 15-15-15, 20-10-10-2S-1Zn, 25-10-10 and 27-13-13 which are commonly found in market **[2].** With exemption of N.P.K. 15-15-15, the fertilizer has N, P and K in the ratio 2:1:1 with higher nitrogen content. Crop quality is improved by adequate use of fertilizer provided that they are applied in accordance with the latest concept and knowledge. Quality of crop includes not only the presence of quality components but also the absence of unwanted surplus nutrient and toxic substances in plant product.

Tomatoes lend themselves well to small-scale and part-time farming operations. Many marketing opportunities are available for small-scale growers with multiple fruit colors (red, yellow, orange, and purple) and heirloom varieties, making it easier for growers to find niche markets **[3].**

Tomatoes originated in South America—specifically in Peru, Bolivia, and Ecuador. Columbus and other explorers brought tomatoes to Europe by the late 1400s. In Europe and the United States, tomatoes were used only as ornamental plants until the early 1800s because the fruit was thought to be poisonous. Tomatoes are a member of the botanical family *Solanaceae,* which contains many potentially poisonous plants (nightshade, nicotianas [includes tobacco and petunias], Jimson weed [belladonna], and mandrake), as well as edible plants (potatoes, capsicums, and eggplants). All members of this family have toxic alkaloids present in either their leaves or their fruits. Commercial tomato production did not begin until after 1860 when tomatoes were finally accepted by consumers. Since 1890, tomato breeding has developed varieties adopted for use around the world **[4].**

Tomato is a short time vegetable crop grown mainly for its edible, like other vegetables, tomato plays a very important role in human diet supplying some of nutrients deficiency in other food materials, it contains essential body building materials and also an important source of proteins and vitamins **[5].**

The various problems and constraints affecting tomatoes could be averted by the use of appropriate cultivars in suitable localities and the use of recommended practices such as early sowing, mulching, transplanting, staking, application of fertilizer, pesticides application and other improved crop husbandry practices **[6].**

Azotobacter is the ability of the bacteria to "fix" atmospheric nitrogen, by the conversion of this elemental form to ammonia. Plants are able to utilize the ammonia as a nutrient. Furthermore, like the bacteria *Klebsiella pneumoniae* and *Rhizobium leguminosarum,*

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Azotobacter vinelandii is able to accomplish this chemical conversion when the bacteria are living free in the soil. In contrast to *Rhizobium leguminosarum*, however, *Azotobacter vinelandii* cannot exist in an association with plants.

Azotobacter is a genus of usually motile, oval or spherical bacteria that form thick-walled cysts and may produce large quantities of capsular slime. They are aerobic, free-living soil microbes which play an important role in the nitrogen cycle in nature, binding atmospheric nitrogen, which is inaccessible to plants, and releasing it in the form of ammonium ions into the soil (nitrogen fixation). *Azotobacter chroococcum* is a bacterium discovered in 1901 by Martinus Beijerinck, noted for his discovery of an infectious agent smaller than a bacterium which is responsible for tobacco mosaic disease, as well as his role in founding the field of virology. It has the ability to fix atmospheric nitrogen, and was the first aerobic, free-living nitrogen fixer discovered. **[7].** *A. chroococcum* is a microaerophilic bacterium, which is able to fix nitrogen under aerobic conditions. To do so, it produces three enzymes (catalase, peroxidase, and superoxide dismutase) to "neutralise" reactive oxygen species. It also forms the dark-brown, water-soluble pigment melanin at high levels of metabolism during the fixation of nitrogen, which is thought to protect the nitrogenase system from oxygen. can round up and thicken their cell walls, to produce what is termed a cyst. A cyst is not dormant, like a spore, but does allow the bacterium to withstand conditions that would otherwise be harmful to an actively growing vegetative cell. When in a cyst form, *Azotobacter* is not capable of nitrogen fixation. The second environmentally adaptive feature of the bacterium is the large amounts of slime material that can be secreted to surround each bacterium. Slime naturally retains water. Thus, the bacterium is able to sequester water in the immediate vicinity.

The need to enhance growth and yield of tomatoes has necessitated the use of fertilizers on the crop. Also, using nitrogen fixing, free living microbes have also been exploited to increase nitrogen nutrition. Information on the use of organic fertilizer and soil microbes is poorly documented. The objectives of this paper were to determine the yield of tomato in response to organic based and mineral fertilizer and to determine growth hormone production in tomato inoculated with *Azotobacter croococcum*.

MATERIALS AND METHODS

The experiment was carried out at the experiment plot of The College of Education, Lanlate (Teaching and Research Farm), Oyo State, Nigeria during the rainy season of 2016. The experimental design used was Randomized Complete Block Design (RCBD) with three replicates. Experimental site was 23m X 9.5m (218.5m^2). There were six treatments; Control (C), Cassava waste - based organic fertilizer (OBF) 5tonnes/ha, Cassava waste - based organic fertilizer + *Azotobacter croococcum* (OBF+AC), Mineral fertilizer (MF), N: P: K 20:10:10 (60kg/ha), Mineral fertilizer + *Azotobacter croococcum* (MF+AC) and *Azotobactcr croococcum* (AC).

Azotobacter croococcum Innoculluni Preparation

The isolate of *Azotobacter croococcum* was obtained from the root rhizospher soil of

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tomato using Jensen medium. The treatments were randomly allotted to each of the plots measuring 3m x 2.5m (7.5m^2) with 1m space in between each plot and block. The soil used for seedlings raised was properly sterilized at the green house to kill pathogens that could inhibit germination and growth of the seeds.

The seeds were sown in the sterilized soil filled in the nursery bowls. The seedlings were transplanted at the age of three weeks after sowing at the spacing of 30cm x 90cm. The treatments were applied at a week after transplanting. Management practices like weeding was done as at when due or required after transplanting. Ten plants were randomly selected and tagged per plot for data collection. The parameters taken were plant height 3WAT and 5WAT.

Harvesting of matured fruits was taken once in a week and recorded against each treatment per replicate and yield parameters were taken as well.

Plants were analyzed for growth hormone in the laboratory and other data collected were subjected to analysis of variance (ANOVA) of SAS (2004) and the means were separated using the New Duncan Multiple Range Test (DMRT) 2004.

RESULTS AND DISCUSSION

Table 1: Result of the pre-planting Soil Analysis

Parameter	Soil Sample
pH	6.7
Organic Carbon	0.99%
Organic Matter	0.62%
Nitrogen (N)	0.08%
C/N Ratio	12.38
Calcium	1.88 cmol/kg
Magnesium	4.36 cmol/kg
Phosphorus (P)	0.26mg/kg
Potassium (K)	0.30cmol/kg
Sodium (Na)	0.45cmol/kg
H^+	0.08
CEC	4.15 cmol/kg
Zinc	9.25 mg/kg
Sand	74%
Silt	20%
Clay	6%

The result of the pre-cropping soil chemical analysis showed that the soil was slightly acidic, with the soil pH of 6.7. The soil was loamy sand (Table 1). The soil has a low percentage N content of 0.08, which is suitable to test free N- fixing bacterium like Azotobacter croococcum.

The exchangeable bases of Ca, K, Na, Mg were found to be 1.88cmol/kg^{-1}, 0.30cmol/kg^{-1}and 1.44cmol/Kg^{-1} respectively. The available P of (MgKg-1) found in the soil was low (Table 1).

Table 2: Average Plant Height (Cm) of Tomato

TREATMENTS	3 WAT	5WAT
C	27.637^{ab}	42.103^{ab}
AC	24.223^{ab}	37.223^{c}
MF	30.707^{a}	48.917^{a}
OBF	27.487^{ab}	43.557^{ab}
OBF + AC	22.520^{b}	48.967^{a}
MF + AC	23.550^{b}	47.337^{a}

At 3 WAT, there was significant increase in plant growth in tomato fertilized with mineral fertilizer (30.717) when compared with the organic base fertilizer + *Azotobacter*

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croococcum, mineral fertilizer + croococcum and the rest (Table 2). Also at 5WAT, there was significant increase in plant height of tomato treated with organic base fertilizer + *Azotobacter croococcum mineral* fertilizer + *Azotobacter croococcum* with the tomato treated with *Azotobacter croococcum*, organic base fertilizer and control (Table 2). The result is consistence with the study carried out at the department of Agronomy University of Ibadan who developed a poultry based urea-fortified organomineral fertilizer **[8].** The organomineral fertilizers were found to increase yield, nutrient content and nutritional quality of maize and vegetables **[9].** The agronomic and economic evaluation of five organomineral fertilizers (OMF) which involved combination of poultry manure-sorted refuse-phosphate rock and urea was studied in field experiment at University of Ibadan.

[1] concluded that the best combination for the combined use of urea and SSP fertilizer application on tomato growth is 50kg/ha urea + 60kg/ha SSP, while that of yield is 100kg/ha urea + 180kg/ha SSP. 0kg/ha urea + 60kg/ha SSP performs best in their study. It improves plant height, number of branches, stem girth, numbers of leaves, number and weight of fruits. Sequel to the findings from this study soil amendment with urea and SSP fertilizer application is recommended for optimum crop productivity of tomato cultivation in south western Nigerian agro ecological zone.

Table 3: Effect of treatment on dry weight of shoot and dry weight of roots of tomato

TREATMENTS	Dry weight of shoot (g)	Dry Weight of Root (g)
C	5.739^{b}	0.8856^{b}
AC	4.758^{b}	0.8800^{b}
MF	10.290^{ab}	1.6600^{a}
OBF	13.329^{a}	0.7722^{b}
OBF + AC	6. 1 00^{b}	1 .0433^{ab}
MF + AC	6.034^{b}	1.1911^{ab}

$P<0.05$

In table 3, it was indicated that organic based fertilizer OBF produced the largest amount of shoot. The weight was significantly higher than any of the other treatments. Over 4g/plant (4.76g/plant) was obtained when only *Azotobacter croococcum* (AC) was applied to the crop. Root weight of tomato fertilized with Mineral Fertilizer (MF) was greatest. The weight was significantly higher than control (C) by 30.42%. A greenhouse work by **[10]** was conducted using two soil types collected from Ikorodu and Ojoo in Lagos State with amaranthus. The treatments were pacesetter organic fertilizer (PGB), ground kola pod husk (GPH) used alone or combined with NPK fertilizer (NPK) at 50:50 or 75:25. Compared with control, the organic and organomineral fertilizers significantly increased growth of amaranthus with integrated application of organic and inorganic fertilizers given highest yield and residual effect. Combined applications also most improved nutritional quality (proximate analysis) and nutrients content [8, 10].

Table 4: Effect of treatment on yield of tomato

TREATMENTS	Yield /plant (g)

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C	41.49
AC	37.25
MF	46.74
OBF	42.54
OBF + AC	40.85
MF + AC	41.81

The tomato fertilized with Mineral Fertilizer (MF) had the greatest yield (46.74t/ha). The weight was significantly higher than that obtained when *Azotobacter croococcum*(AC) was combined with Mineral Fertilizer (MF) (Table 4).

[11] confirmed that Urea alone increased soil OM, N, P, K, Ca and Mg relative to the control. This could be due to enhanced nucrobial activity (due to surge in N availability) that led to enhanced production and mineralization of organic matter from natural (native) source in soil. However urea reduces soil pH due to its acid producing nature.

[12] also reported that application of poultry manure at 5tha-1 and farm yard manure at 5-10tha-1 supplemented with 50kgNha-1 resulted in adequate crop growth and maximum fruit yield of pepper (*Capsicum annum* L) and water melon [C*itrullus lanatus* (Thum.)

[13] reported that combined application of sub-optimal rates of NPK fertilizer and poultry manure enhanced plant performance compared with application of NPK fertilizer or poultry manure alone. The yield target for Onion, Tomato, Hot and Sweet Pepper were under achieved by 70, 81, 68, and 76 percents respectively. The organic matter target was under achieved by 83 percent while, the phosphorous and PH targets were over achieved by 35 and 4 percents respectively. **[14]**

[15] showed that potassium fertilizer had a significant effect on the fresh weights of leaves and stems, early and total yield of sweet pepper plants. The concentration uptake of nutrients by crop could be influenced by their availability. In pepper **[8]** plant uptake of nutrients had been reported to have direct relationship with soil nutrient contents. However, use of nitrogen fertilizer brings about an increase in crop yields and consequently an increase in farm income

CONCLUSION

Azotobacter can accomplish nitrogen fixation by using three different **enzymes** , which are termed nitrogenases. The enzyme diversity, and an extremely rapid metabolic rate (the highest of any known living organism) allow the bacterium to fix nitrogen when oxygen is present. The other nitrogen-fixing bacteria possess only a single species of nitrogenase, which needs near oxygen-free conditions in order to function. The enhanced versatility of *Azotobacter* makes the microbe attractive for agricultural purposes.

Organic and organo-mineral fertilizers have been reported to significantly increase yield of vegetables such as pepper (*Capsicum annum*), tomato (*Lycopersicon esculentus*), okra (*Abelmoschus esculentus*), egusi-melon (*Cucumeropsis mannii*) and amaranthus (*Amaranthus cruentus*). Most farmers apply these assorted types of fertilizers (organic and inorganic) but sometimes the yields hardly

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compensate for the money spent to purchase these fertilizers. This is partly because most farmers are yet to determine the best local fertilizer source to use in the vegetable crop production. **[16].** It is concluded that growth and yield of tomato were significantly increased by the used of Mineral fertilizer (MF), though Organic based fertilizer (OBF) has the highest dry weight of shoot. Mineral fertilizers also maintain its significant increased in dry weight of root. In the treatment with *Azotobacter croococcum* (AC), there were no much significant in plant height, dry weight shoot and root as compared to Mineral fertilizer (MF).

Results of a greenhouse pot experiments with onion showed that application of *G. fasciculatum* + *A. chrooccocum* + 50% of the recommended P rate resulted in the greatest root length, plant height, bulb girth, bulb fresh weight, root colonization and P uptake **[17]. [18]** concluded that with microbial inoculation rock phosphate could be used as cheap source of P in alkaline soils and that combined inoculation could reduce the rate of fertilizer required to maintain high productivity. A study by **[19]** on the production of growth substances by nine *Azotobacter chroococcum* strains isolated from a chernozem soil has showed that these strains have the ability to produce auxins, gibberelins, and phenols and in association with the tomato plant, increase plant length, mass, and nitrogen content. *Azotobacter chroococcum* produces an antibiotic which inhibits the growth of several pathogenic fungi in rhizosphere thereby seedling mortality **[20]**. Under greenhouse conditions inoculation of *Azotobacter chroococcum* recorded a significant N and P uptake in both seed and stover in Brown sarson over the control **[21]**

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